STANDARD OPERATING PROCEDURE

FOR

ROUTINE OPERATION OF THE API MODEL 400A OZONE ANALYZER FOR CONTINUOUS GAS CONCENTRATIONS OF OZONE IN CRPAQS

STI-99214

By:
Nicole P. Hyslop
Ann E. (Beth) Wittig
Sonoma Technology, Inc.
1360 Redwood Way, Suite C
Petaluma, CA 94954-1169

February 22, 2000

[TABLE OF CONTENTS

Section **Page**

LIST OF TABLES

1. SCOPE AND APPLICABILITY

The API Model 400A ozone analyzer can be used to measure ozone concentrations between 0 and 20,000 ppb. The instrument operates in a continuous mode.

2. SUMMARY OF METHOD

The detection of ozone molecules is based on absorption of 254 nm UV light due to an internal electronic resonance of the O_3 molecule. The Model 400A uses a mercury lamp constructed so that a large majority of the light emitted is at the 254 nm wavelength. Light from the lamp shines down a hollow quartz tube that is alternately filled with sample gas, then filled with gas scrubbed to remove ozone. The ratio of the intensity of light passing through the scrubbed gas to that of the sample forms a ratio I/I_0. This ratio forms the basis for the calculation of the ozone concentration.

The Beer-Lambert equation, shown below, calculates the concentration of ozone from the ratio of light intensities.

$$C_{O_3} = -\frac{10^9}{a \times l} \times \frac{T}{273\text{K}} \times \frac{29.92\text{inHg}}{P} \times \ln \frac{I}{I_0}$$

Where: I = Intensity of light passed through the sample
I_0 = Intensity of light passed through sample free of ozone
a = absorption coefficient = 308 cm^{-1} atm^{-1}
l = path length
C_{O3} = Concentration of ozone in ppb
T = sample temperature in Kelvin
P = Pressure in inches of mercury.

The effects of temperature and pressure are addressed by directly measuring them and including their actual values in the calculation. Temperature and pressure influence the density of the sample. Density fluctuations alter the number of ozone molecules in the absorption tube, which changes the amount of light absorbed from the light beam.

Every six seconds the M400A completes a measurement cycle consisting of a two-second wait period for the sample tube to flush, followed by a one second measurement of the UV light intensity to obtain I. The sample/reference valve is switched to reference mode, allowing the sample to pass through a scrubber, where all ozone is removed. The scrubbed sample then flows through the sample tube for two seconds followed by a one-second measurement of the UV light intensity to obtain I_0. Measurement of I_0 every 6 seconds minimizes instrument drift due to changing intensity of the lamp as a result of aging and dirt. The concentration of ozone is then

computed using the Beer-Lambert equation. Next, the concentration is automatically corrected using the slope and offset, which are set during each zero/span calibration.

Corrected concentration = Slope × Measured Concentration + Offset

Finally, an average of the last thirty-two samples is computed. This rolling 192-second (6 seconds samples times 32 samples) average is the ozone concentration displayed on the panel and routed to the DAS.

3. DEFINITIONS

Words written in all capital letters within the SOP correspond to buttons on the front panel or messages on the display panel.

The following are abbreviations are used in this SOP:

AC = Alternating current

DAS = Data acquisition system

EPA = Environmental Protection Agency

IZS = Internal Zero/Span

O_3 = Chemical formula for ozone

PTFE = Polytetrafluoroethylene

SOP = Standard operating procedure

UV = Ultraviolet

Table 1. Model 400A ozone analyzer data parameter abbreviations and definitions.

Parameter Abbreviation	Units	Definition
PHMEAS	mV	Last photometer reading when sample gas was in the optical bench
PHREF	mV	Last photometer reading when reference gas was in the optical bench
SLOPE1	N/A	Slope determined from most recent span calibration
OFSET1	ppb	Zero offset determined from most recent zero calibration
ZSCNC1	ppb	Concentration during calibration used to compute the slope and offset
PHTEMP	^{o}C	Photometer lamp temperature
O3CNC1	ppb	Ozone concentration
STABIL	ppb	Ozone concentration stability, based on the standard deviation
O3REF	mV	Ozone generator reference reading
O3DRIV	mV	Ozone generator drive
O3TEMP	^{o}C	Ozone generator lamp temperature
SMPTMP	^{o}C	Sample temperature
SMPFLW	cc/min	Sample flowrate
SMPPRS	in Hg	Sample pressure
VACUUM	in Hg	Vacuum pressure
BOXTMP	^{o}C	Internal box temperature
DCPS	mV	DC power supply output

Table 2. Model 400A Ozone Analyzer operational warning abbreviations and definitions.

Warning Abbreviation	Definition
PHREFW	Photometer reference warning
PHTMPW	Photometer lamp temperature warning
O3REFW	Ozone generator reference warning
O3LMPW	Ozone generator lamp intensity warning
O3TMPW	Ozone generator lamp temperature warning
STEMPW	Sample temperature warning
SFLOWW	Sample flow warning
SPRESW	Sample pressure warning
BTEMPW	Internal box temperature warning
DCPSW	DC power supply warning

4. HEALTH & SAFETY WARNINGS

- Never disconnect any instrument circuit boards while under power.
- Hazardous voltages are present on the power supply module. Always disconnect the AC power cord from the instrument before attempting to remove or replace any parts.
- UV light is generated inside the instrument. Do not pull the lamp from the IZS assembly.

5. CAUTIONS

- Connect the exhaust fitting on the rear panel to a suitable vent outside the analyzer sampling area.
- Sample pressure should not exceed 1.5 in-H_2O over ambient. The calibration line vent should always be open when calibration gases are sent to the O_3 analyzer. This will allow excess calibration gas to exit and avoid build-up of pressure in the calibration lines to the ozone analyzer.
- Sample gas should only come into contact with PTFE, quartz, or glass. Leak check all fittings with soap solution.
- Check that analyzer is set up for proper voltage and frequency.
- Power plug must have a ground lug.
- Allow a minimum of 4 inches of clearance at the back of the instrument and 1 inch of clearance on each side for proper ventilation, when installing the instrument.

6. INTERFERENCES

The UV absorption method for detecting ozone is subject to interference from a number of sources. The Model 400A has been successfully tested for its ability to reject interference from sulfur dioxide, nitrogen dioxide, nitric oxide, water, and meta-xylene. Although the instrument rejected interference from the aromatic hydrocarbon meta-xylene, there are a large number of volatile aromatic hydrocarbons that could potentially interfere with ozone detection.

7. PERSONNEL QUALIFICATIONS

This SOP along with the instrument manual should suffice to train the field technician to operate and maintain the ozone analyzer. All personnel have been introduced to the methodology behind air quality measurements and the goal of this monitoring study.

8. APPARATUS & MATERIALS

- The API Model 400A O_3 analyzer can be operated between 5-40oC, as defined by the EPA. The temperature will be measured continuously inside the shelter. If the temperature is ever outside of the appropriate range, the data will be marked invalid.
- A humidity range of 10-90% is acceptable for running the instrument. Sample gas should only come into contact with Teflon, quartz, or glass. Leak check all fittings with soap solution.
- Teflon tubing, fittings, and solenoid valves are used to attach the analyzer to the sampling and calibration lines. The calibration and sampling lines are fed into the two inlets of the 3-way solenoid valve, while the single outlet runs to the analyzer.
- The O_3 analyzer is attached to the data acquisition system using a cable with a 9-pin, female connector. The cable should be attached to the assigned port on the DAS, according to the DAS SOP.
- The only tools required for installation are screwdrivers for installing the instrument to the rack and 9/16” and 1/2” wrenches for tightening the tube fittings.
- Activated carbon is used to filter the scrubbed inlet air to the instrument and should be replaced regularly as described in Section 14.
- A particulate filter is located internally on the inlet of the instrument and should be changed according to Section 14.
- Don’t use a mercury thermometer near the inlet of the instrument. If the thermometer breaks near the inlet of the instrument and mercury enters the system it takes forever for the analyzer to recover.

9. SITE & EQUIPMENT PREPARATION

- Off site equipment acceptance
    - Verify that there is no apparent external or internal shipping damage. Inspect the interior of the instrument to make sure all circuit boards and other components are in good shape.
    - Remove the two red shipping screws on the outside cover of the instrument and the four red shipping screws from the optical bench assembly inside the instrument. Reinstall these screws whenever the instrument is shipped.
    - Connect a clean, dry air supply to the inlet in the back of the instrument labeled DRY AIR.
    - Turn on the instrument power.
    - Often, the front panel LED labeled FAULT will be flashing, indicating an error, and the error message will say SYSTEM RESET. If this occurs, simply clear this error by pressing the soft key directly below CLR of the front panel.
    - Allow the instrument to warm up for approximately 30 minutes. During this time temperatures and other conditions are out of specification. The software will suppress most warning conditions for 30 minutes after power up. Use the CLR soft key on the front panel to clear warning messages.
    - After 30 minutes, check the TEST function by comparing the values listed in Table 2.1 of the manual to those in the display. Each TEST function is described in detail in the manual. All of the readings should compare closely with those in the Table 2.1 of the manual. If they do not, refer to Section 9 in the manual or Section 15 in this SOP.
- Off site pre-deployment equipment test
    - After allowing the instrument to operate for several days (if the instrument is brand new, it should be operated for several days, otherwise several hours will suffice), a zero and span calibration should be performed. Following, the zero/span calibration, a manual multi-point calibration should be performed to establish the external calibration equation of the instrument. The calibration is performed using the calibrator. A modular calibrator will be used to perform all multi-point calibrations. The analyzer sample inlet should be connected directly to the calibrator output using Teflon tubing. These procedures are described in detail in Section 10.
- On-site equipment acceptance
    - The same procedure should be followed on-site as was followed off-site.

- On-site equipment installation

  - The API Model 400A O_3 Analyzer will be installed in an instrument rack at the CRPAQS field site. The hardware to attach the instrument was included with the initial shipment.

- On-site connection of equipment to data acquisition system

  - The Model 400A ozone analyzer RS-232 interface will be used to collect monitoring data and control the analyzer remotely. A cord with a 9-pin, female connector must be attached to the RS-232 port of the analyzer. The other end of the cord must be attached to the assigned port on the DAS board. On the back of the instrument, just to the left of the RS232 port, there is a switch. The switch should be in the DTE position if a null modem cable is not used and in the DCE position if a null modem cable is used. If you are having communication problems, make sure that this switch is in the appropriate position. Details on data transfer from the ozone analyzer to the data acquisition are included in Section 16.

- On-site connection of equipment to calibration system

  - The analyzer will be connected to the calibrator via Teflon tubing and a 3-way solenoid valve. The line from the calibrator will be fed to one inlet of the solenoid valve, and the line from the outlet of the solenoid valve will be attached to the inlet of the analyzer. The solenoid valve will be controlled by the DAS.

  - A three-way solenoid valve will be used to feed calibration gases or ambient air to the instrument exclusively. All of the inlet tubing must be made of Teflon. The common port of the solenoid valve should be connected to the inlet of the ozone analyzer. The normally closed port of the solenoid valve should be connected to the calibration manifold. The normally open port of the solenoid valve should be connected to sampling manifold.

- On-site equipment test

  - After allowing the instrument to operate for several hours a multi-point calibration should be performed on the instrument.

10. INSTRUMENT OR METHOD CALIBRATION

10.1 FIVE-POINT CALIBRATIONS

The instrument will undergo a five-point calibration every three months. Each quarter, the site operator will bring an independent calibrator in and attached it directly to the ozone

analyzer. Each time a calibration is performed, a new calibration curve will be generated. A calibration curve consists of plotting the actual ozone concentrations versus the analyzer output value. A linear, least squares fit is applied to these five points using Excel, generating a linear calibration equation used to adjust the data. Application of this calibration equation to the data is described in Section 16.

Table 3. Five point calibration sequence concentrations and times.

Ozone Concentration (ppb)	Run Time (minutes)
0	20
60	15
120	15
180	15
240	15

10.2 ZERO/SPAN CALIBRATIONS

The instrument will undergo a zero/span calibration followed by a five-point calibration after any major maintenance procedures are performed. The instrument should always be allowed to run for at least 30 minutes before a calibration is performed. Zero/span calibrations will be performed manually. The calibration gases are sent through the sample port. Table 4 describes each of the steps in the zero/span calibration. The span value should be programmed in the calibrator and analyzer to 240 ppb (80% of full scale), when operating in a range of 0-300 ppb. Detailed operation of the calibrator is described in the calibrator SOP.

Table 4. Zero/span calibration steps.

Calibration Step	Time	Calibrator Action	Ozone Analyzer Action
Zero Calibration	0	Start zero gas flow at approximately 5 lpm	Press CAL soft key to enter calibration mode
	20		Press ZERO to zero the instrument[1]
Span Calibration	0	Start span gas flow (240 ppb) at approximately 5 lpm	
	15		Press SPAN to span the instrument[1,2]

[1] If the ZERO or SPAN, which ever is appropriate, soft key is not displayed, this means that the zero reading is too far out of adjustment to do a reliable calibration. The reason for this must be determined before the analyzer can be calibrated. Refer to Section 15 of this SOP or Section 9.2 of the instrument analyzer for troubleshooting help.
[2] The span concentration must be programmed into the instrument only once, as long as the value doesn't change. If the span concentration is ever changed or if you want to check the span concentration, press the **CAL** soft key followed by the **CONC** soft key. The span concentration should be displayed and can be edited if desired.

11. SAMPLE COLLECTION OR INSTRUMENT OPERATION

The instrument automatically begins sampling once it is plugged in and the power is turned on. The internal pump operates as long as the instrument is operating, and the instrument operates in continuous mode. The instrument requires 30 minutes to warm up after the power is turned on. The data will be collected and stored as 1-minute averages by the data acquisition system. The instrument display should be checked on a regular basis for any errors. Error reporting is described in Section

11.1 NIGHTLY ZERO/SPAN CHECKS

Zero/span checks will be performed automatically at the same time every night and take approximately 30 minutes. The steps are summarized in Table 5. The zero check consists of purified air from the calibrator passing through the analyzer for fifteen minutes. The first ten minutes allow the instrument to stabilize and generate accurate zero values. The final five minutes will be averaged, by the data manager, to provide the zero value. During this time, the measurements are recorded by the DAS every minute as usual. If the zero measurement deviates from zero (0.0) by more than 5 ppb, the instrument will be checked, repaired, adjusted, and recalibrated as required. Immediately following the zero check, a span check will be performed. The span check consists of sending 80 ppb of ozone from the calibrator to the ozone analyzer for twelve minutes. The last five, one-minute measurements will be averaged, by the database manager, to provide the span reading. Then, the zero value should be subtracted from the span reading, and the corrected span reading compared to the actual value of 80 ppb. If there is more than a 10% difference between the corrected span value and the actual value, the instrument will be checked, repaired, adjusted, and recalibrated as required. The most likely cause of an ozone analyzer's poor span response is instability in the ozone concentrations from the calibrator. Refer to the troubleshooting section for help. Following the span check, the sampling lines will again be opened and the instrument will return to normal operation. The first three minutes of data following a zero/span check will be considered invalid data, because of the time needed to purge the lines of calibration gases.

Table 5. Nightly zero-span ozone calibration check.

Time	Calibrator Action	Acceptable Analyzer Response
0-15 minutes	Send zero air to the analyzer	+/- 5.0 ppb = -5.0 ppb $\leq O_{3,zero} \leq$ 5.0 ppb, where $O_{3,zero}$ is the analyzer response to zero gas
15-27 minutes	Send 80 ppb O_3 to the analyzer	Adjusted measurement within +/- 10% of actual value $\frac{O_{3,span} - O_{3,zero}}{O_{3,input}} \leq 10\%$, where $O_{3,span}$ is the analyzer response to span gas and $O_{3,input}$ is the actual ozone concentration output by the calibrator

12. PREVENTIVE MAINTENANCE & REPAIRS

A few maintenance procedures must be performed on a regular basis to ensure proper operation of the API Model 400A O_3 Analyzer. Table 1 summarizes the procedures and timing. Each of these procedures is described in detail in Section 8 of the analyzer manual. The most frequent procedures are described in the following sub-sections.

Table 3. Summary of routine maintenance to be performed on the ozone analyzer.

Procedure	Timing for procedure
Replace sample filter (Teflon)	Weekly or as needed
Check the sample inlet for orientation and contamination	Weekly or as needed
Replace IZS zero air scrubber (charcoal)	Every 6 months
Replace pump diaphragm	Every 12 months
Inspect and clean, if necessary, sample cell	Every 12 months
Check sample flow	Every 12 months
Replace O_3 scrubber	Every 2 years
Replace IZS zero air filter	Every 2 years
Leak check	After maintenance is performed

12.1 CHANGING THE SAMPLE FILTER

The sample filter must be changed weekly to avoid contaminating the sample air. The filter is located in the front left quarter of the instrument. The filter can be accessed through the front panel. Pulling on the two pegs on the top of the front panel opens the front panel. Be careful not to pull down the front panel without adjusting the tubes to allow movement. The filter is located under the round glass piece mounted to the left side of the panel. Unscrew the black rim around the glass piece and remove the glass cover. The large o-ring holds the filter in place. Remove the old filter. Note in the logbook if the filter seems especially dirty. The filters have a plastic coating on one side. The coated side must be placed downward in the holder. Install a new filter making sure that the backing is points towards the bottom of the instrument. Secure the cover back into place and close the front panel.

12.2 CHECKING THE SAMPLE INLET

The sample inlet for the ozone analyzer should be checked on a weekly basis. There are a few things that must be checked with respect to the inlet. The top of the ambient air inlet must be orientated downward to avoid entraining water. Make sure there is no dirt or water built up in the inlet lines. Also, the fittings along the inlet line and the calibration line should be checked every few weeks to ensure that there is not a leak.

13. TROUBLESHOOTING

The API Model 400A analyzer has a few different signaling systems to indicate instrument status and diagnose problems. First, three status LED's are located on the front of the display. The various states and corresponding meanings of these LED's are summarized in Table 4.2 of the manual. Second, a series of TEST functions, which show key analyzer operating parameters, can be viewed on the display panel. Table 2.1 in the manual lists the desired values for these TEST functions. The test values can be viewed using the cursor arrows below the display to advance through each of the values. Each of the individual values is displayed in the center of the display. Third, the analyzer provides descriptive warning messages for the most common and/or serious instrument failures. These fault diagnostics are summarized in Table 9.2 of the manual. Finally, the instrument features a diagnostic mode that can be used to aid in troubleshooting the instrument. Table 9.3 of the manual describes all of the diagnostic mode signals.

13.1 CALIBRATION CHECK OUT OF ACCEPTABLE RANGE

The most common problem encountered with the ozone analyzer will be that the calibration check is not within the necessary specifications. Several steps should be taken before the calibration parameters (slope and offset) are ever changed. First, make sure that the sample filter on the inlet of the instrument is clean. Replacement of the filter is described in Section 12.1. Next, the gas lines from the calibrator to the ozone analyzer should be checked for leaks. This can be done by running zero air to the analyzer from the calibrator and applying soap solution to the lines. If soap bubbles form, the line is leaking at that point. Next, make sure that the zero air generator outlet pressure is set to 45 psig. After checking these points, run a manual zero-span calibration check and watch the data from both the calibrator and analyzer. Check the results for acceptable responses. If the responses are acceptable, watch the calibrations closely over the next few days, but do not make any changes. If the responses are not acceptable, look at the calibration checks from several previous nights/weeks to determine if this response fits a trend or is a sudden change. If there is another monitoring instrument that uses ozone for calibrations, also look at those calibrations over the previous days/weeks to determine if the response is resulting from the analyzer or the calibrator. Consult the troubleshooting section of the manual for further guidance.

13.2 TEST PARAMETERS OUT OF RANGE

13.2.1 O_3 MEAS and O_3 REF Out of Acceptable Range

The test parameters will be checked weekly, and it is likely that the O_3 MEAS and O_3 REF values will drop out of range. The parameters are typically drop severely within the first few weeks of service and then slowly decline. Once the values drop close to 2000 mV, they should be reset using the pot inside the instrument. The procedure is described in Section 9.3.5.1

of the instrument manual. Note the O_3 REF and O_3 MEAS values before starting the procedure. Remove the cover from the instrument. In the front of the instrument bench is a silver cover, remove the cover. The pot, referred to as pot #7 although there is only one pot, is located under this cover. Press the TST> soft-key until the O_3 REF value appears on the screen. Adjust the pot until the O_3 REF value is approximately 4500 mV. Check that the O_3 MEAS value is also close to 4500 mV. Following this procedure, a five-point calibration should be performed.

14. DATA ACQUISITION, CALCULATIONS, AND DATA REDUCTION

Data will be collected from the instrument every minute. The instrument is programmed to automatically send the Julian date and time along with three parameters: ozone concentration (O3CNC1), sample flowrate (SMPFLW), and photometer lamp voltage (PHMEAS). This set of parameters is established in an internal analyzer data channel labeled CRPAQS. The instrument data channels are described in detail in Section 5.3.3.1 of the instrument manual or in the separate document named Built-in Data Acquisition System Manual. Parameters can easily be added or deleted from this continuous output by modifying the data channel in the analyzer. This data will be stored at the on-site computer. On a daily basis, the ozone concentration data will be downloaded to a remote computer at STI. The only data that will be saved in the STI database is the ozone concentrations, which will be converted to five-minute averages from the one-minute averages. The calibration equation determined from the most recent five-point calibration will be applied to each data point to calculate the actual ozone concentration. The calibration equation is computed by plotting the actual concentration versus the displayed concentration and then applying a least squares curve fit. The resulting slope and offset can be applied to the output data according to the following equation:

$$[O_3]_{actual} = \text{slope} \times [O_3]_{output} + \text{offset}$$

where: $[O_3]$actual = the calibrated ozone concentration
$[O_3]$output = the ozone concentration read by the analyzer
slope and offset = the calibration equation slope and offset calculated following the last five-point calibration.

Instrument warnings will automatically be sent to the data acquisition system as they occur. Each of the instrument warnings has a unique set of parameters that will be reported to aid in diagnosing the problem. The parameters that are reported with each warning are summarized in Table 2. The specific instrument warnings will not be transmitted to STI; instead the data will be flagged to indicate that an error has occurred. The specific instrument warnings will be saved on-site and can be downloaded manually, if necessary.

Table 4. Instrument warnings and corresponding parameters that will be sent to the DAS as they occur. The warning and parameter abbreviations are defined in Section 3.

Warning	Parameters
PHREFW	PHMEAS, PHREF, PHTEMP
PHTMPW	PHTEMP, SMPTMP
O3REFW	O3REF, O3DRIVE, O3TEMP
O3LMPW	O3DRIVE, O3TEMP
O3TMPW	O3TEMP, SMPTMP
STEMPW	SMPTMP, SMPFLW
SFLOWW	SMPFLW, SMPPRS, VACUUM
SPRESW	SMPPRS, VACUUM, SMPFLW
BTEMPW	BOXTMP, SMPTMP
DCPSW	DCPS

15. COMPUTER HARDWARE & SOFTWARE

The API Model 400A ozone analyzer has flexible, programmable software associated with it. The software is described extensively in Section 5 of the instrument manual. The parameters output by the instrument can be individually chosen and adjusted. Also, the timing of any output can be selected.

16. DATA MANAGEMENT & RECORDS MANAGEMENT

Ozone concentration, sample flowrate, and photometer voltage data will be collected from the ozone analyzer every minute. This minutely data will be held in a daily data file. These data files will be queried and downloaded to STI every day. When the instrument data is queried, only the ozone concentrations will be copied and downloaded to STI on a nightly basis.

Every ozone analyzer will have an instrument logbook associated with it. All regular maintenance, changes in setup, manual calibrations performed, repairs made, abnormal measurement, missing or failed calibration check, power failures, etc. should be noted in the logbook. In addition, weekly checklists will be filled out and put into the logbook. A sample checklist is included at the end of this document.

Calibration check analyses will be performed at STI on a daily basis. Quarterly calibration curves will be plotted and applied to the ambient data at STI, also. The operators are expected to view the zero/span calibration check data every morning and recognize missing/troublesome data.

Task Table 1: API 400A Ozone Analyzer Quick Reference Sheet.

(Detailed procedures and troubleshooting for each task follow the Task Table 1 and are listed by task number.)

Task		Frequency	Performance parameter	Task Guidance	Troubleshooting Guidance
1	**Check nightly zero-span response**	Daily	Zero within +/- 5 ppb Span +/-10% of input concentration	Task 1	Task 1
2	**Check for instrument errors**	Daily	N/A	Task 2	Task Tables 3 and 4
3	**Check instrument settings:** TEST values	Weekly	Task Table 3	Task 3	Task Table 3
4	**System maintenance**	Weekly or as needed	N/A	Task 4	N/A
4a	Replace sample filter				
4b	Check the sample inlet for orientation and contamination				

Required materials:

- Replacement filters required and must be changed weekly.
- Inlet cleaning materials (paper towels, cotton-tipped swabs, water, soap).

Task 1. Check nightly zero and span response

Zero/span checks will be performed automatically at 02:45 every night and take approximately 30 minutes. The steps are summarized in Task Table 2.

Task Table 2. Nightly zero-span ozone calibration check.

Time	Calibrator Action	Acceptable Analyzer Response
0-15 minutes	Send zero air to the analyzer	+/- 5.0 ppb = -5.0 ppb $\leq O_{3,zero} \leq$ 5.0 ppb, where $O_{3,zero}$ is the analyzer response to zero gas
15-27 minutes	Send 80 ppb O_3 to the analyzer	Adjusted measurement within +/- 10% of actual value $\frac{O_{3,span} - O_{3,zero}}{O_{3,input}} \leq 10\%$, where $O_{3,span}$ is the analyzer response to span gas and $O_{3,input}$ is the actual ozone concentration output by the calibrator

The zero check sends purified air from the calibrator to the analyzer for fifteen minutes. The first ten minutes allow the instrument to stabilize and generate accurate zero values. The

final five minutes will be averaged to provide the zero value. During this time, the measurements are recorded by the DAS every minute as usual. If the zero measurement deviates from zero (0.0) by more than 5 ppb, the Field Manager should be notified. The instrument will be checked, repaired, adjusted, and recalibrated as required.

Immediately following the zero check, a span check will be performed. The span check sends 80 ppb of ozone from the calibrator to the ozone analyzer for twelve minutes. The last five, one-minute measurements will be averaged to obtain the span reading. The zero value should be subtracted from the span reading to obtain the corrected span reading. The corrected span reading should be compared to the actual value of 80 ppb. If there is more than a 10% difference between the corrected span value and the actual value, the Field Manager should be notified. The instrument will be checked, repaired, adjusted, and recalibrated as required. The most likely cause of an ozone analyzer's poor span response is instability in the ozone concentrations from the calibrator.

Following the span check, the sampling lines will be opened and the instrument will return to normal operation. The first three minutes of data following a zero/span check will be considered invalid data, because of the time needed to purge the lines of calibration gases.

Task 2: Check for instrument errors

The API Model 400A analyzer has a few different signaling systems to indicate instrument status and diagnose problems. The methodology listed below should be followed to check for errors.

- Check the status LED's – if the "fault" LED is not red or flashing then there are no errors.
- Make a note of the warning message on the front panel on the Worksheet.
- Refer to **Task Table 3** to identify possible problems. Use the TEST function to monitor current parameters to help in the diagnosis. The TEST function is located on the bottom left hand side of the instrument display. The buttons are identified by the <TST TST> above them. Toggle through the different TEST values by pressing these buttons.

Three status LED's. The status is located on the front of the display. The various states and corresponding meanings of these LED's are summarized in **Task Table 4**. If the 'Fault" LED is not red or flashing then the instrument has not detected any errors during its self tests.

Fault diagnostics. The analyzer provides descriptive warning messages for the most common and/or serious instrument failures. These fault diagnostics are summarized in Task Table 3. Finally, the instrument features a diagnostic mode that can be used to aid in troubleshooting the

instrument. Contact the CRPAQS Field Manager if there are any warnings. Additional guidance is provided in the Manual in Table 9.3.

TEST functions. A series of TEST functions which show key analyzer operating parameters, can be viewed on the display panel. Task Table 3 lists all of the acceptable values for these TEST functions. The test values can be viewed using the cursor arrows below the display to advance through each of the values. Each of the individual values is displayed in the center of the display.

Task Table 3. Model 400A ozone analyzer TEST values.

Parameter Abbreviation	Units	Factory Values	Acceptable Range	Definition	Troubleshooting Guidance
RANGE	ppb	500	100 – 10,000	Full scale range of analog outputs	N/A
STABIL	ppb	0.5	0.2 – 1.0	Ozone concentration stability	N/A
O3 MEAS	mV	4155.9	4200 – 4700	Ozone concentration	N/A
O3 REF	mV	4173.9	4200 – 4700	Ozone generator reference reading	O3 GEN REF WARNING – Refer to Manual 9.3.9
O3 GEN	mV		0 – 75 (O_3 gen off) < 75 (O_3 gen on)	IZS feedback reference detector option	O3 GEN LAMP WARNING – Refer to Manual 9.3.9
O3 GEN DRIVE	mV	967.4	0 – 5000	Ozone generator drive	N/A
VACUUM	inHg		< ½ of SAMPLE PRES	Vacuum pressure	N/A
SAMPLE PRES	inHg	28.5	28 – 30	Sample pressure	SAMPLE PRES WARNING – Refer to Manual 9.3.10
SAMPLE FLOW	cc/min	815	720 – 880	Sample mass flowrate	SAMPLE FLOW WARNING – Refer to Manual 9.3.10 and 10.6.1
SAMPLE TEMP	°C	41.1	10 – 15 above ambient	Sample temperature	SAMPLE TEMP WARNING – Refer to Manual 9.3.2
PHOTO LAMP	°C	52.0	51.5 – 52.5	The temperature of the UV source lamp	PHOTO REF WARNING and PHOTO LAMP TEMP WARNINGs – Refer to Manual 9.3.5
O3 GEN TEMP	°C	48.1	47.5 – 48.5	The temperature of the IZS ozone generator lamp	O3 GEN TEMP WARNING – Refer to Manual 9.3.9
ORIFICE TEMP	°C	48	48	Orifice manifold temperature	ORIFICE TEMP WARNING – Check heater and/or thermistor
BOX TEMP	°C	27.1	1 – 5 above ambient	Internal box temperature	BOX TEMP WARNING – Refer to Manual 9.3.2
DCPS	MV	254.8	2250 – 2750	DC power supply output	N/A
SLOPE	N/A	1.009	1.0 +/- 0.1	Software gain term	N/A
OFFSET	ppb	-2.3	0 +/- 5	Software zero offset term	N/A
TIME	N/A	Current	00:00 – 23:59	Time-of-day clock	Reset the time

Task Table 4. Model 400A ozone analyzer Status LEDs.

LED	State	Meaning	Use in CRPAQS
Green (Sample)	On	Monitoring normally, sending data to DAS	Normal
	Off	Not monitoring, not sending data to DAS	Problem, notify Field Manager
	Blinking	Monitoring, not sending data to DAS	Problem, notify Field Manager
Yellow (Cal)	On	Auto cal disabled	Normal
	Off	Auto cal enabled	Not used, notify Field Manager
	Blinking	Calibrating	Not used, notify Field Manager
Red (Fault)	Off	No warnings exist	Normal
	Blinking	Warnings exist	Problem, notify Field Manager

Task 3: Check instrument settings - TEST values

The key analyzer operating parameters can be viewed on the display panel using the <TST and TST> soft-keys. Each of the individual values is displayed in the center of the display.

The TEST value abbreviations and definitions are listed in Task Table 3. Record the values of each of the parameters on the worksheet. The worksheet lists the acceptable values for each of these TEST values. If any of the parameters is outside of the acceptable range, note the difference on the worksheet and contact the Field Manager.

Task 4: System maintenance

Task 4a. Changing the sample filter

The sample filter must be changed weekly to avoid contaminating the sample air. The filter is located in the front left quarter of the instrument. The filter can be accessed through the front panel. Pulling on the two pegs on the top of the front panel opens the front panel. Be careful not to pull down the front panel without adjusting the tubes to allow movement. The filter is located under the round glass piece mounted to the left side of the panel. Unscrew the black rim around the glass piece and remove the glass cover. The large o-ring holds the filter in place. Remove the old filter. Note in the logbook if the filter seems especially dirty. The filters have a plastic coating on one side. The coated side must be placed downward in the holder. Install a new filter making sure that the backing is points towards the bottom of the instrument. Secure the cover back into place and close the front panel.

Task 4b. Checking the sample inlet

The sample inlet for the ozone analyzer should be checked on a weekly basis. There are a few things that must be checked with respect to the inlet. The top of the ambient air inlet must be orientated downward to avoid entraining water. Make sure there is no dirt or water built up in the inlet lines. Also, the fittings along the inlet line and the calibration line should be checked every few weeks to ensure that there is not a leak.

Contact information:

CRPAQS Field Manager

Beth Wittig
Sonoma Technology, Inc.
Bakersfield Operations Center
2718 Ardee Circle
Bakersfield, CA 93304
(661) 837 - 4219
(661) 837 - 4219 fax
(661) 203 - 1082 cell
beth@sonomatech.com

Ozone Measurement Expert

Nicole Hyslop
Sonoma Technology, Inc.
1360 Redwood Way, Suite C
Petaluma, CA 94954
(707) 665 - 9900
(707) 665 - 9800 fax
nicole@sonomatech.com

Instrument:	API 400A Ozone Analyzer
Worksheet:	Task 1 - Check nightly zero and span response (daily) Task 2 - Check for instrument errors (daily)
Site Code:	

Date	/ /	/ /	/ /	/ /	/ /
Field Tech					
Instrument SN					
INITIAL CHECKS:					
Time					
DAS clock (PST)	: :	: :	: :	: :	: :
O3 clock (PST)	: :	: :	: :	: :	: :
1.) CHECK NIGHTLY ZERO AND SPAN RESPONSE:					
Was a 5-min zero achieved?	Yes / No	Yes / No	Yes / No	Yes / No	Yes / No
Zero (ppb)					
Start time (PST) / End time (PST)	/	/	/	/	/
Was a 5-min span achieved?	Yes / No	Yes / No	Yes / No	Yes / No	Yes / No
Span (ppb)					
Start time (PST) / End time (PST)	/	/	/	/	/
Comments					
2.) CHECK FOR INSTRUMENT ERRORS:					
Is red "fault" LED flashing?	Yes / No	Yes / No	Yes / No	Yes / No	Yes / No
Warning message					
Comments					
RECORDKEEPING:					
Printed graph?	Yes / No	Yes / No	Yes / No	Yes / No	Yes / No

Instrument:	API 400A Ozone Analyzer
Worksheet:	Task 3 - Check instrument settings: TEST values (weekly) Task 4 - System maintenance (weekly)
Site Code:	

Date		/ /	/ /	/ /	/ /	/ /
Field Tech						
Instrument SN						
INITIAL CHECKS:						
DAS clock (PST)		: :	: :	: :	: :	: :
Ozone clock (PST)		: :	: :	: :	: :	: :
3.) INSTRUMENT CHECKS: TEST VALUES						
Parameter	Acceptable range					
Stabil (ppb)	0.2 - 1.0					
O3 meas (mV)	2000 - 4700					
O3 ref (mV)	2000 - 4700					
O3 gen (mV)	0 - 5000					
O3 drive (mV)	0 - 5000					
Vacuum (in Hg)	< 15					
Press (in Hg)	25 - 35					
Samp Fl (cc/min)	720 - 880					
Sample temp (C)	20 - 45					
Photo lamp (C)	51.5 - 52.5					
O3 gen lamp (C)	47.5 - 48.5					
Orofice temp (C)						
Box temp (C)	8 - 50					
Dcps (mV)	2400 - 2600					
Comments						
4.) SYSTEM MAINTENANCE:						
Filter changed?		Yes / No	Yes / No	Yes / No	Yes / No	Yes / No
Roof inlet checked?		Yes / No	Yes / No	Yes / No	Yes / No	Yes / No
Comments						